Lake Erie Shore Erosion

A Solution for Conneaut's Shoreline Recession Problem

A Thesis

Presented for Fullfillment of the Requirements

for the Degree of Bachelor of Science

by

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Abstract

The ever-present recession of the Lake Erie shoreline makes the formation of a plan to slow the action of erosion essential. Several factors combine to increase the downslope movement of land into the lake. Excess drainage adds weight and water to the bluff, enhancing slump and weathering of the topsoil. Lack of vegetation allows rainwater to create runoff and gullies on the unstable slope of glacial sediments. Waves attack the base of the slope, thus transporting the sediment that has been displaced by gravity. These factors sum to a net loss of three feet per year of valuable property along the shoreline.

This study deals with the natural erosional processes and gives possible solutions to abate shore recession. The suggestion for the area in Conneaut, Ohio between Harrington Point and Salisberry Road includes proper drainage techniques, added vegetation to the bluff, and the construction of a series of groins on the beach. These structures will not stop erosion, but should slow the recession rate from three feet per year to almost one foot per year. The residences on this stretch of shore are valuable enough to consider an investment in shore protection in order to save the aesthetic values of this site for future generations.

I want to thank the Laituri family for the use of their property for study, especially David for his help with history and illustrations. I would also like to thank Dr. Ed Herdendorf for his guidance.

Introduction

Shore erosion is a natural geologic process that occurs continuously to shape the form of bluffs and beaches around the world. As Lake Erie shore owners realize, this is not a new or unusual phenonema. An estimated 1200 habitable buildings will be destroyed in the next thirty years because of high levels of precipitation, high lake levels, weathering, wave action, improper drainage and also man's intervention in the erosional process.[1]

The objective of this report is to investigate the causes of shore erosion in Conneaut, Ohio, between Salisberry Road and Harrington Point, and to suggest reasonable preventive measures to forestall the loss of land. The Laituri residence at 1242 Lake Road was used as a sample area of the bluff type found on the eastern south shore of Lake Erie to study stratigraphy, sediment content, wave action, littoral drift, mass wasting, drainage and degradation. These geologic processes combine to cause a loss of three feet of soil per year to the lake.

Several shore protection devices have been installed by private property owners to abate this downslope movemant. Some have been relatively effective, while other structures have broken down with time. Possible solutions will be illustrated and the most effective and inexpensive variety will be recommended for this area to slow inevitable property loss. Hopefully, some misconceptions will be resolved relating to governmental control of the lake levels and problems caused by man's improper use of his shoreline land. The aesthetic values of lakeside residence can be preserved for future generations with some understanding and investment now.

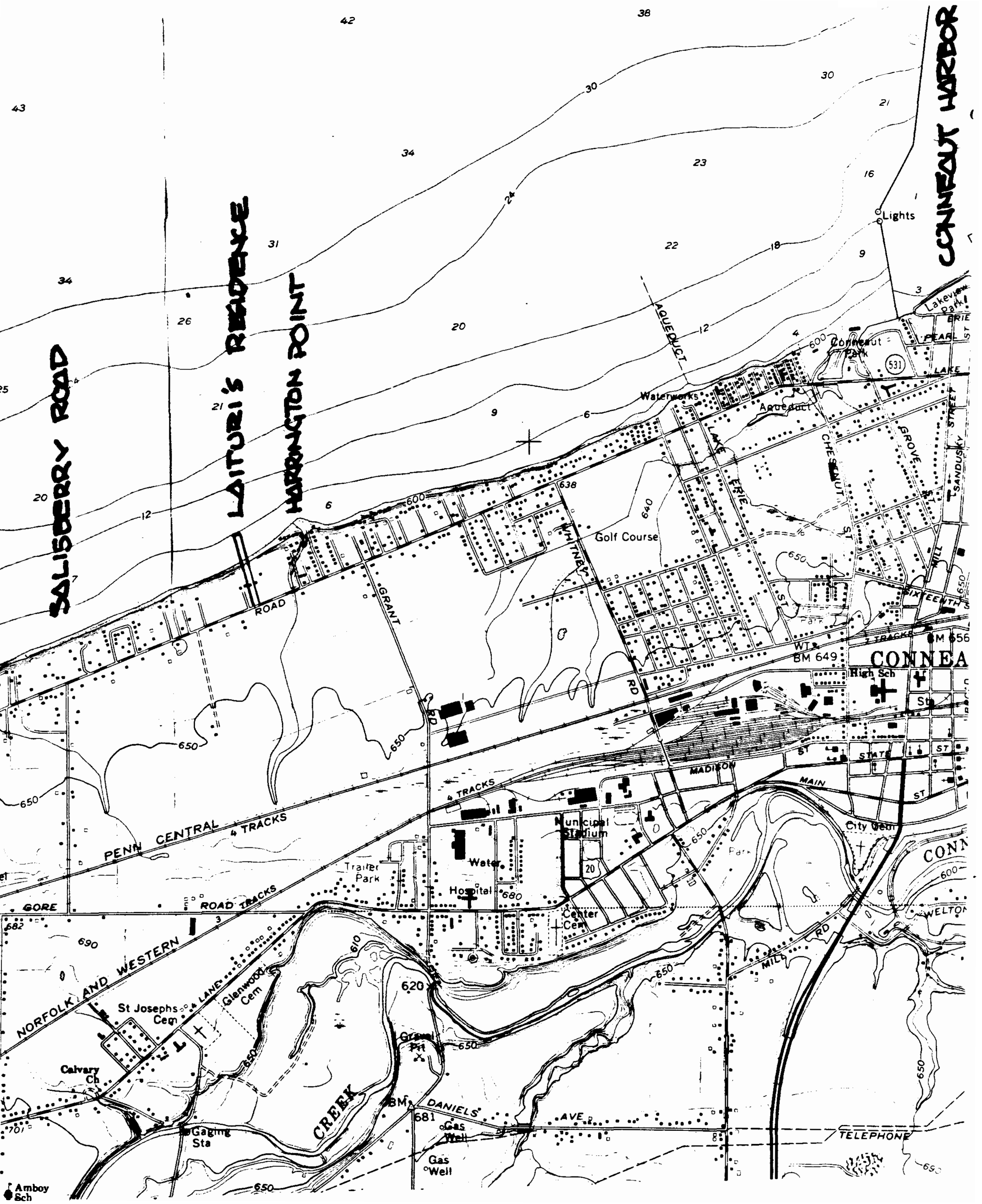


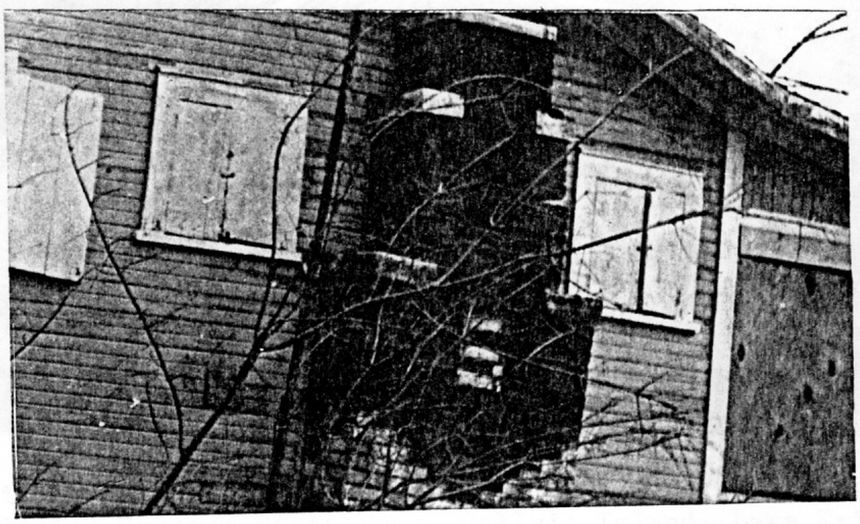
Figure 1. Map of study area. (U.S. Dept of the Interior Geological Survey, 1970).

The landowner who is bound to lose his home has three options:

1. Relocate or sell.
2. Do nothing.
3. Install shore protection devices.

Obviously, the owner of the home below could not invest in time. This house has a dip of approximately 8° and is now uninhabitable. Tension cracks can be seen in the chimney and there is no foundation on the left side. This is a potential danger spot for young children.

A



B

Figure 2A. Abandoned house that is located ten houses east of Laituri's residence. B.Closeup of tension fractures in chimney.

Geologic Setting

Five hundred billion years ago lava bubbled on the surface of North America, which became Lake Erie's base minerals. Seas of the Cambrian system drained and flooded the area, leaving lacrustrine deposits five to ten meters thick. Glaciers advanced from the north decreasing water levels and adding ice to the frozen mass. This powerful stream of ice smashed rocks and scooped deep paths, bulldozing dikes which obstructed river drainage. Glacial till was deposited during the last Wisconsin ice age up to depths of twenty feet. Ten thousand years ago Lake Erie reached its present stage at 358 feet above sea level. [2] Evidence of the glacier is found on Kelly's Island, Lake Erie (Fig.3).

Since it is a drowned river, Lake Erie is the shallowest of the Great Lakes. The storms that occur there are severe and affect the

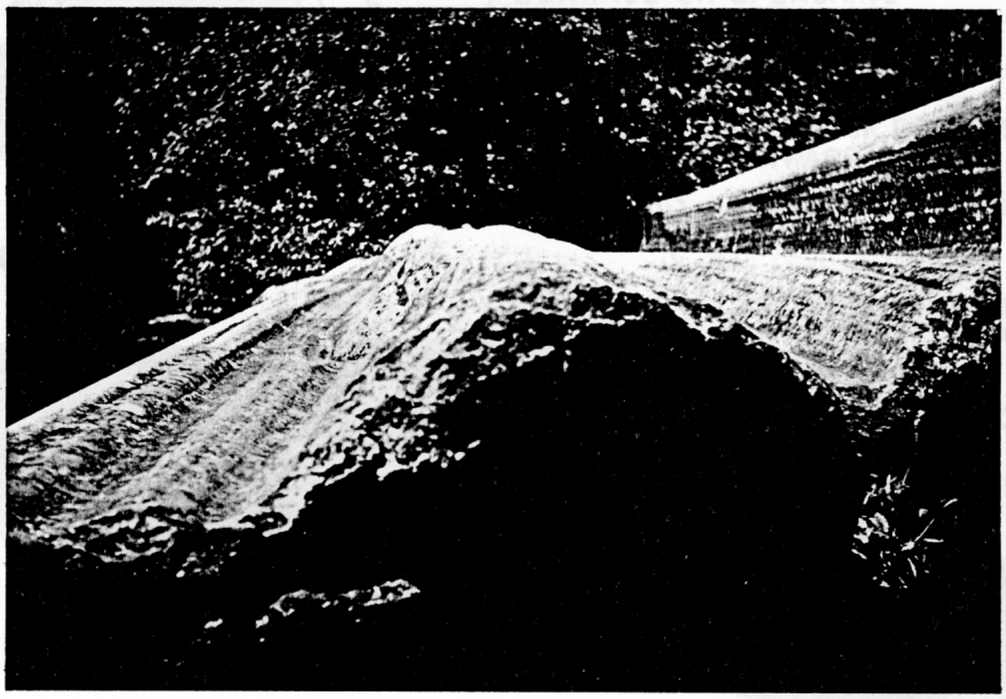


Figure 3. Grooves made in rock by glacial activity. Glacial Grooves State Park, Kelly's Island, Lake Erie.

shore at an accelarated rate. Storms in 1972 and the spring of 1973 caused millions of dollars of damage due to erosion and flooding.[3] The high bluff of twenty meters has a base of old lake sediments, topped by a layer of glacial till. This stratigraphy promotes block mass movement of slump due to lubrication caused by water draining onto the clay layer. Precipitation adds weight to the bluff and pushes land downslope. The high lake levels increase wave action which carries away the toe sediments.

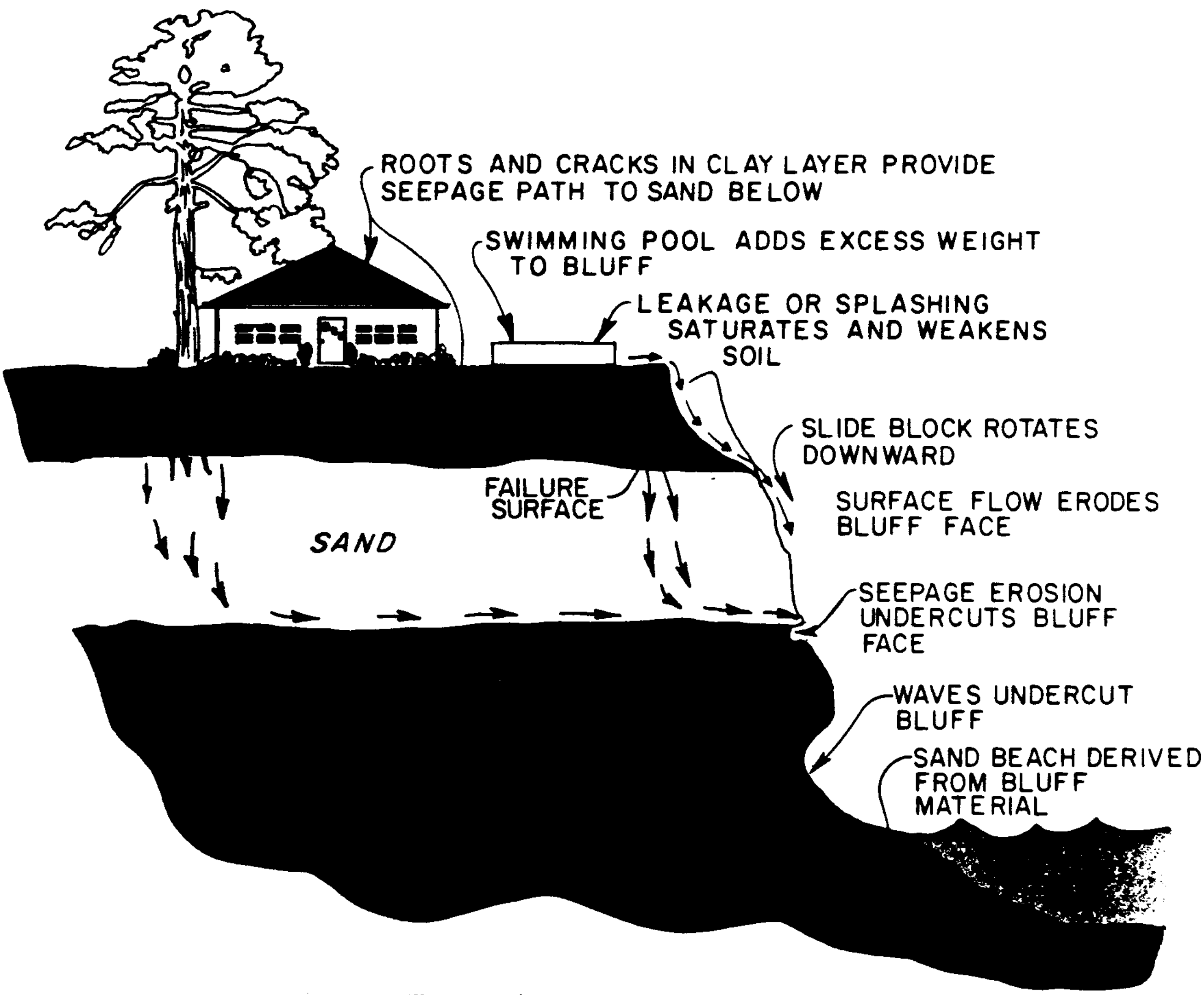


Figure 4. Causes of bluff erosion and retreat. (U.S. Army Corp of Engineers, 1981).

NATURAL PROCESSES

Littoral Drift

Littoral drift is the transport of lake sediment and sand along the shore by prevailing winds and oblique waves(Fig. 5). The direction of transport on Lake Erie in the Conneaut area is northeast because of the prevailing winds in this direction (Fig. 6). Storms come from the northeast and cause the accumulation of sand on the opposite side of a groin than usual. A groin placed perpendicular to the shoreline interrupts the longshore system of transport. If a groin is placed on the south shore of Lake Erie, sand is taken from the east side and deposited on the updrift west side. A field of groins, when constructed the correct distance apart, fill to capacity with sand, reach a state of equilibrium, and create a stable beach. Littoral drift continues at about the same rate as before construction, but causes no more damage to adjacent property. [4] Waves can now break on this beach rather than expending their energy on the bluff toe. [5]

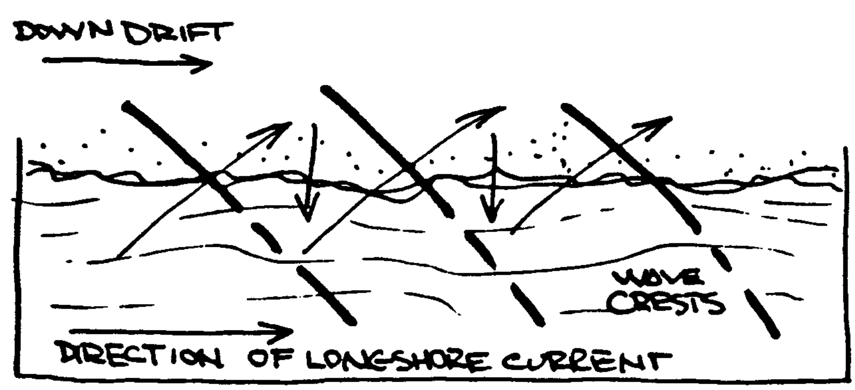


Figure 5. Mechanics of littoral drift. (Taken from U.S. Army Corp of Engineers, 1981).

Ashtabula County

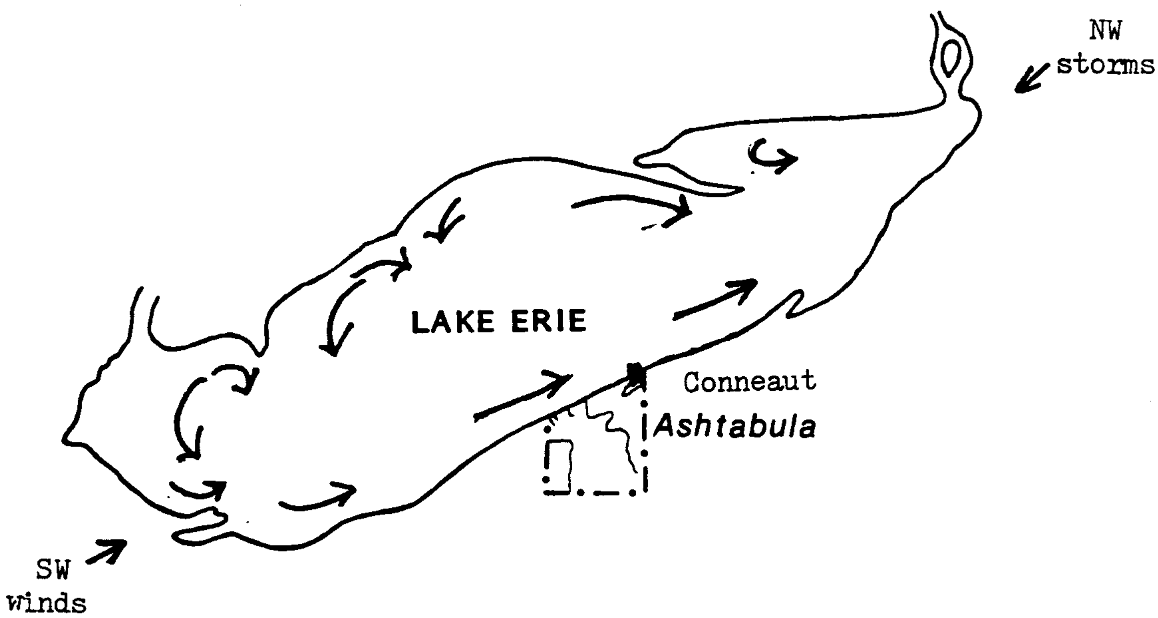


Figure 6. Lake Erie wind direction is prevailing to the northeast and littoral drift proceeds in this direction also. Storms temporarily alter this direction. (Altered from Lichtkoppler, 9/82).

Wave Action

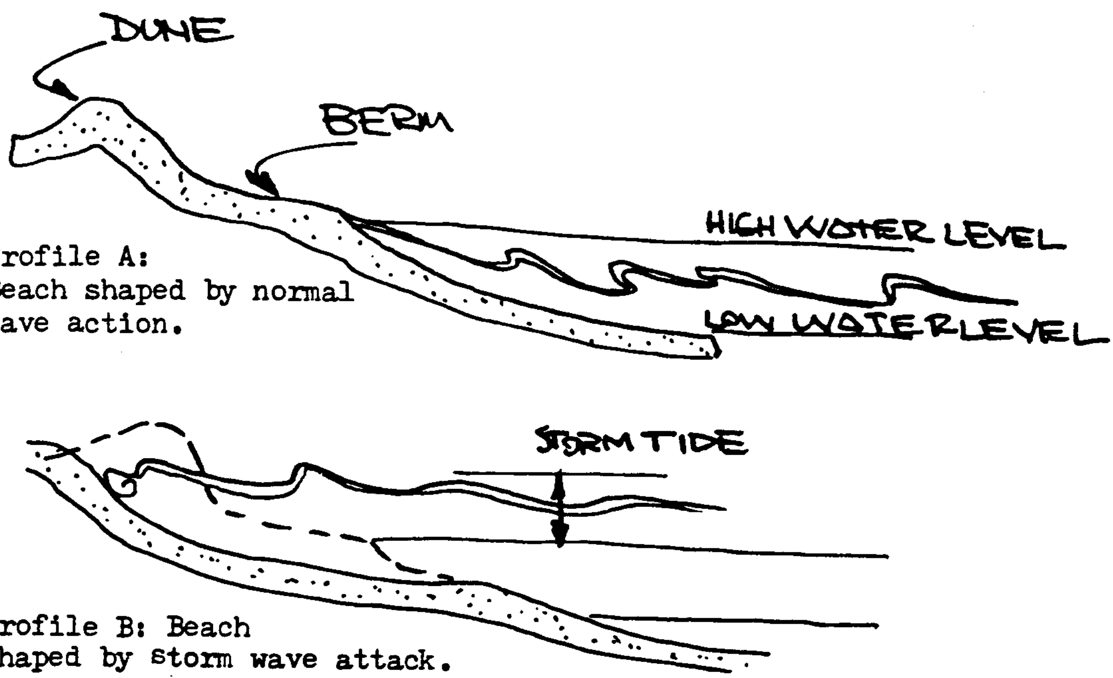
"Waves move in small vertical circles and keep returning to the starting place, while the form and energy of the waves move forward." [6] As the wave nears shore, it hits bottom, breaks, and causes turbulence of the lake floor. Wave action has four major effects on the bluff:

1. Wave scour and abrasion. Sand is placed in motion by the waves.

2. Erosion occurs due to the impact of the wave on the shore.

3. Water is forced into the cracks of the bluff material and increases the hydrostatic pressure, thus dislodging the toe.

4. Waves are agents of transportation of the dislodged sediments, which travel to the lake bottom or to adjacent beaches. [7]

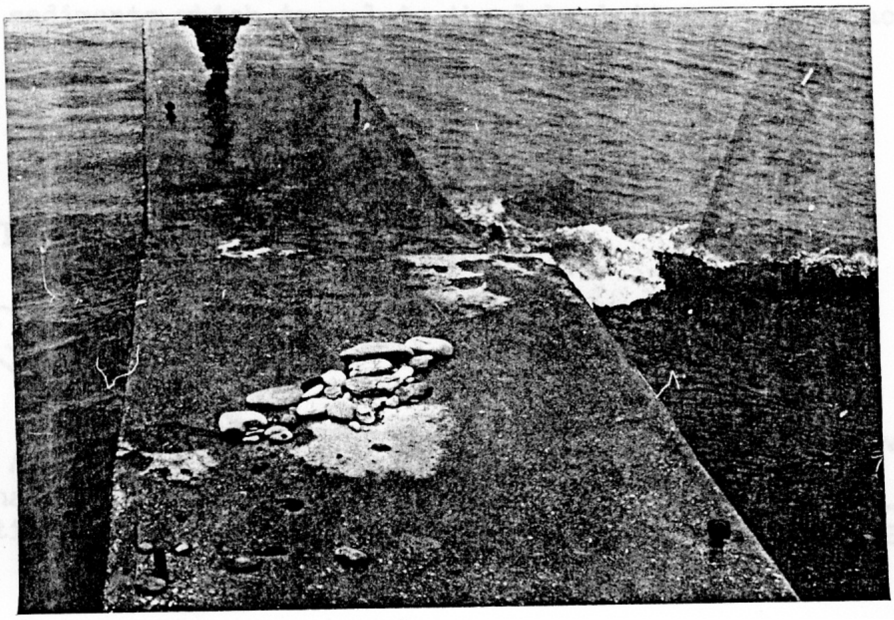


Profile A:
Beach shaped by normal wave action.

Profile B: Beach shaped by storm wave attack.

Figure 7. Wave action. (Taken from U.S. Army Corp of Engineers, 1981).

A



B

Figure 8. Processes occuring at a groin structure located two residences west from Laituri's. (A) Wave action on a typical spring day, March 30, 1983. Normal conditions of one foot waves. (B) Cobble sized crystalline rocks moved to three foot high structure due to wave action. Littoral drift accumulation of fifteen feet can be seen on the updrift side. The wind direction was reversed on this day to the prevailing winds.

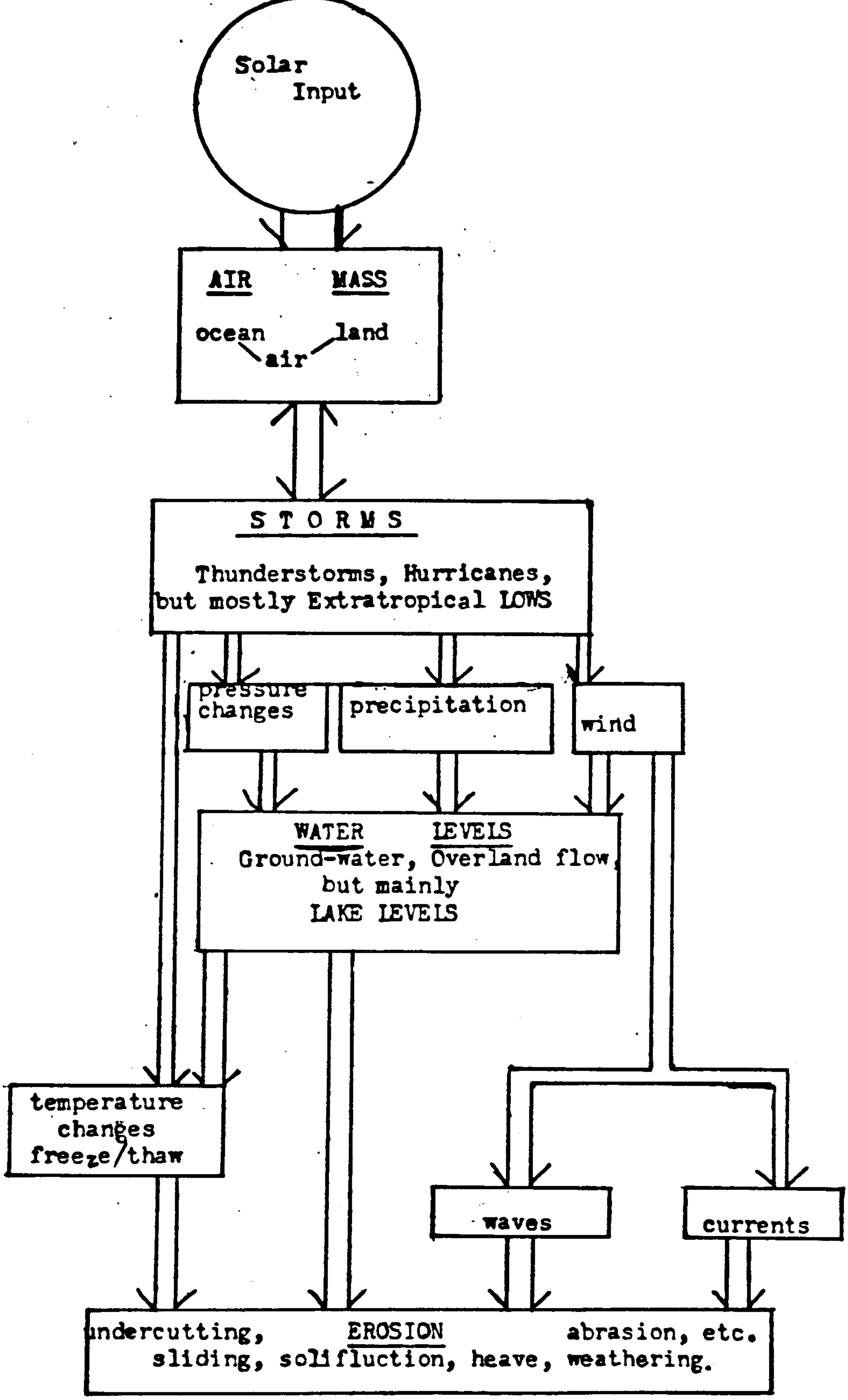


Figure 9. A basic energy flow diagram for Great Lakes shore erosion. Although the water level is the most significant factor in erosion rate, the importance of the other factors will vary according to area studied and the properties of that that area. (Barnett, 1979).

Lake Levels and Storms

A flow diagram of basic energy, starting with the sun and its thermal energy, is shown in figure 9. Storms are created with this energy that causes pressure systems in the atmosphere. Northeast storms are caused by low pressure systems moving south and are largely responsible for wind setup of the west end of the lake.[8] These setups are caused by wind blowing over the fetch of the lake and are termed seiches. During the storm of November 1972, seiches of five feet were present. Twenty-two million dollars were lost because of erosion and flooding during this storm.[9]

Another factor in the increased erosion rate in this storm was the high lake level. The high level in 1972 at four feet above mean-chart-datum-level for Lake Erie equals 572. feet above sea level. The year of 1983 is expected to have levels of 572.1 feet above sea level.[10]

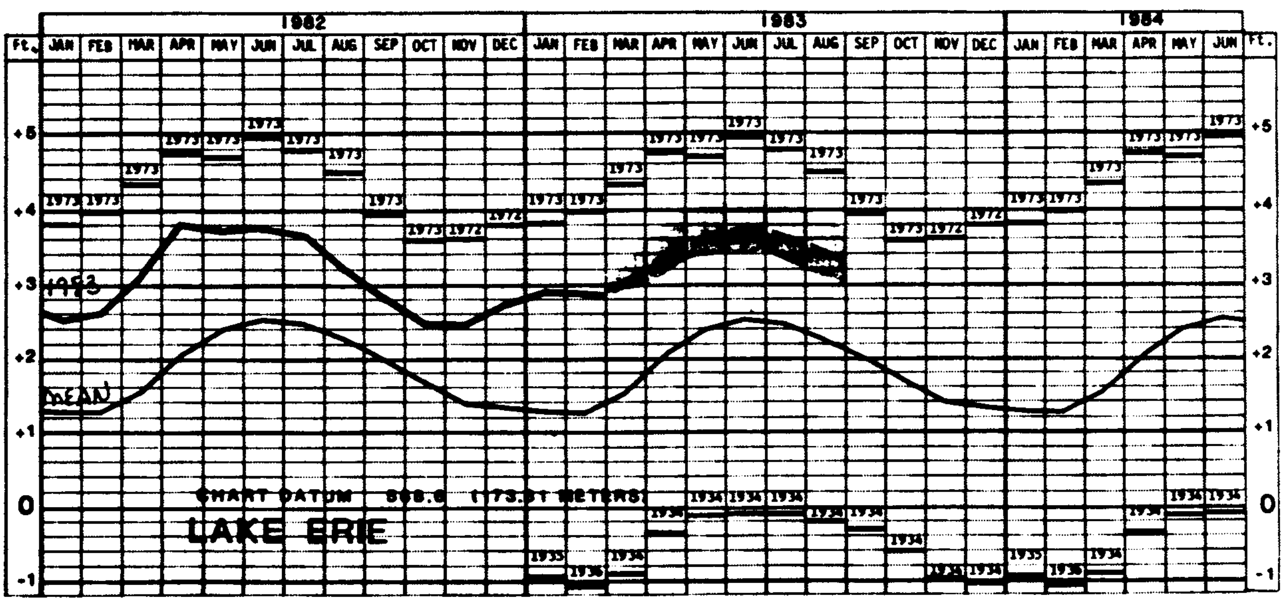


Figure 10. High, mean and future lake levels for Lake Erie. (Department of the Army, Detroit District, 1983).

Another factor affecting the level of Lake Erie is the isostatic rebound of North America resulting from the melting of the glaciers. This crustal movement has tipped the north side of the Lake Erie basin up relative to the south at a rate of .37 feet per year.[11] Although this movement seems negligible, with our recent altered climatic conditions, it is hypothesized that the glaciers may melt even more.

Lake Erie is the shallowest of the Great Lakes and has the second smallest surface area. These reasons and its east-west orientation makes it most likely to be affected by weather. Regulations of the lake levels would be beneficial to property owners as well as the shipping industry. The costs to maintain an even level, however, has exceeded its benefits in the past years, so no regulations have been placed on Lake Erie, contrary to some shore owners beliefs. [12]

Degradation

Degradation is a process of decomposition that weakens the stability of the bluff by physical and chemical weathering and increases the rate of erosion. The agents of weathering include:

1. Temperature changes.
2. Abrasion by wind, water and ice.
3. Organisms (plants, animals, and man).
4. Mechanical effect of chemical weathering.
5. Differential expansion due to release of pressure upon unloading of snow.
6. Pressure resulting from growth of ice crystals in small openings in the soil.
7. Hydration shattering from ice crystals.
8. Water and atmosphere(H_2O, O_2, CO_2, H, etc.). [13]

Chemical weathering increases the bulk of the weathered till, loosens it and renders it suseptible to movement, especially in deep joints, by mass wasting.

On the shoreline these chemical reactions are important:

<u>Oxidation</u> - A typical exothermic, volume-increasing reaction between minerals and the wet atmosphere. Hematite is created from iron-rich minerals, such as pyrite.

<u>Hydrolysis</u> - Feldspar and mica are turned into clay minerals by carbonates.

<u>Hydration</u> - Hematite and pyrite = Limonite and water. Till weathers readily because of the quartz-rich igneous and metamorphic rocks.

<u>Solution</u> - The abundance of groundwater leaches the carbonates. $CO_2 + H_2O = H^+ + HCO_3$(bicarbonate).[14]

<u>Freezing and thawing</u> - (Slaking) This disrupts the silt-rich layer by expansion as ice crystals grow, and contraction as they melt. Wetting and drying causes the clay minerals to crumble (physical weathering).[15] See figure 11.

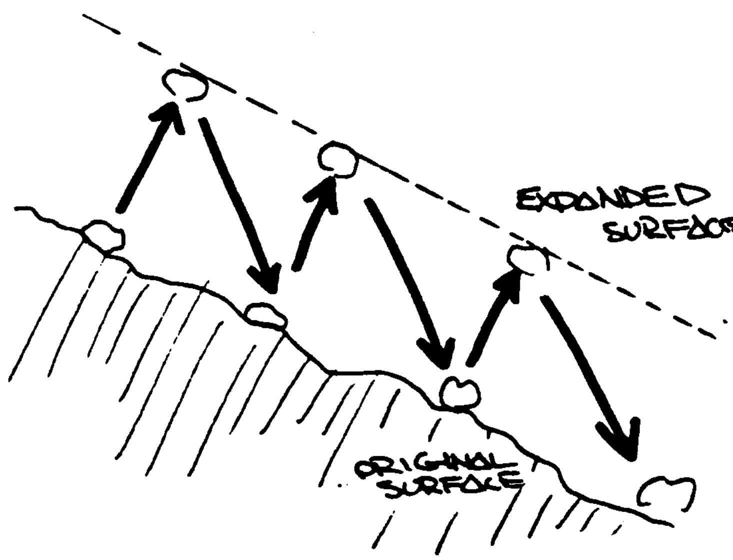


Figure 11. Effects of Freeze-thaw. Result is a net downslope movement. (Bloom, 1980).

Mass Wasting

Two types of mass wasting occur on this Lake Erie bluff. "Slump is a movement along a curved surface(spoon-shaped) of a kind of superficial faulting which leaves an amphitheatre-shaped scar the the landscape."[16] Figure 12 shows the tension cracks that develop on the roof of the bluff as a result of gravity, which shatter the material into large slippage blocks. Waves and rain cause wetting and drying of summer clay. During the drying cycle, this clay consolidates and capillary pressure affects the smaller pores. The clay shrinks and develops polygonal tensional cracks that are another zone of weakness for slump to occur. [17]

Creep is an imperceptible and general movement of soil downslope by gravity. No exact shear surface can be recognized. This displacement is similar to plastic deformation and flowage. [18] The bluff at Laituri's residence is characterized by deep-seated zones of fracture scarps that are actively creeping downhill to establish a more stable slope or a natural angle of repose.

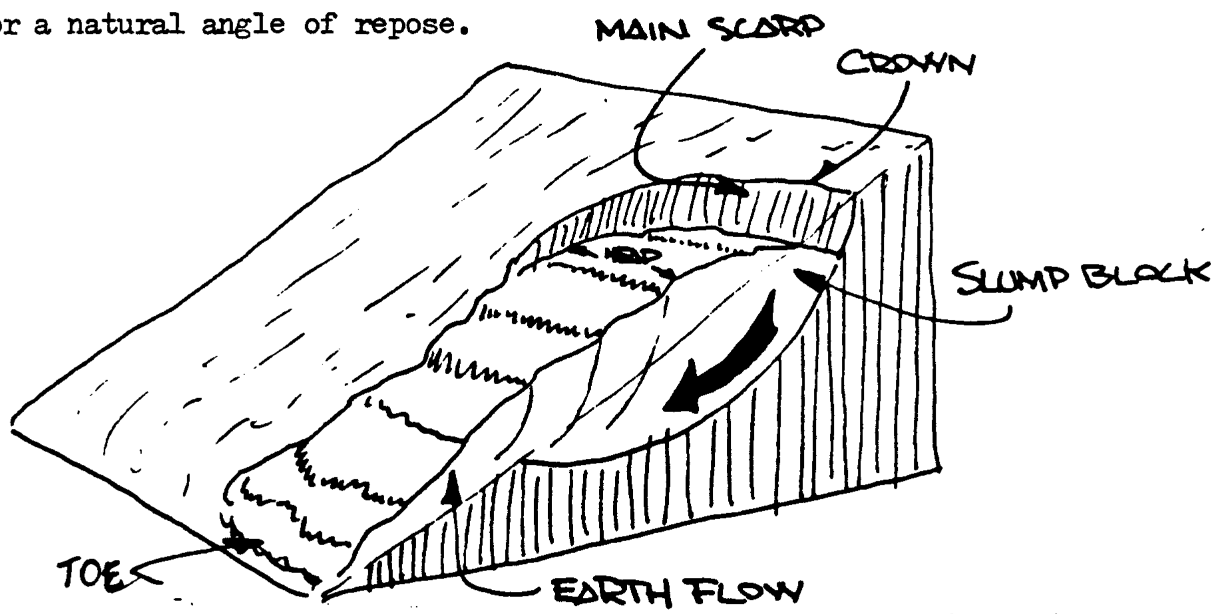
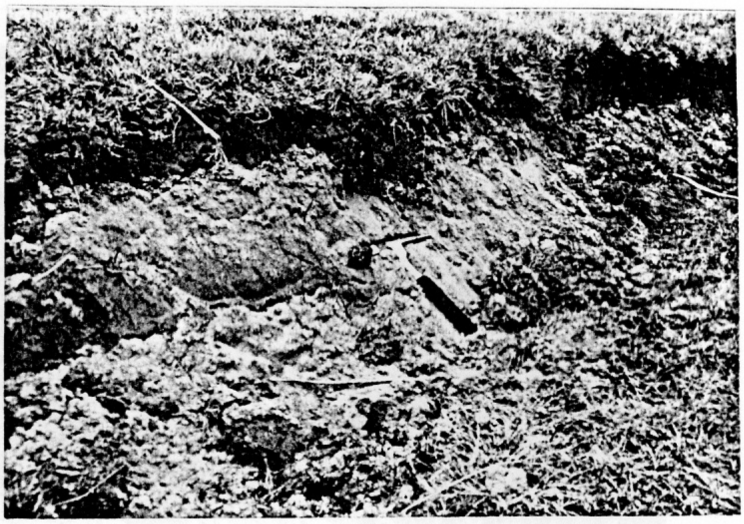


Figure 12. Slump. A rotational movement of blocks of soil due to excess water, gravity, and unstable sediment. (Taken from Bloom, 1980).

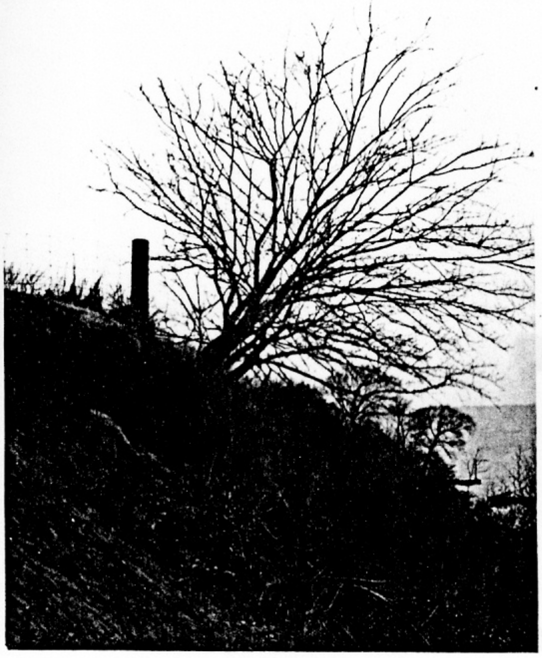
A



B

C

Figure 13. Slump movement observed on Laituri's residence, 1282 Lake Road, Conneaut, Ohio. (A) Newly formed slump division due to snow thaw and added precipitation. Only small tensional fractures could be seen on December 25,1982. (B) Closeup of plane of movement. This photograph was taken in March 1983. There was a movement of 2.4 feet in three months. (C) A slump cave-in due to a substantial spring below. This photograph was taken in August 1982. It is located left of A.



A

B

C

D

Figure 14. The tree in these photos is one residence west of Laituri's property. Measurements for slump rate were taken from the fence post to the far base of the tree along the top surface. (A) In April 1982, one could walk around the fence post safely. This photo (April 1983) shows slump of approximately three feet(See figure 15). Spring thaw and the weight of the tree enhanced rapid slump in the spring. (B)Close-up of the tree base and loss of soil. (C) Rear view of the tree, looking over the bluff. (D) Tensional cracks formed at the base of the post.

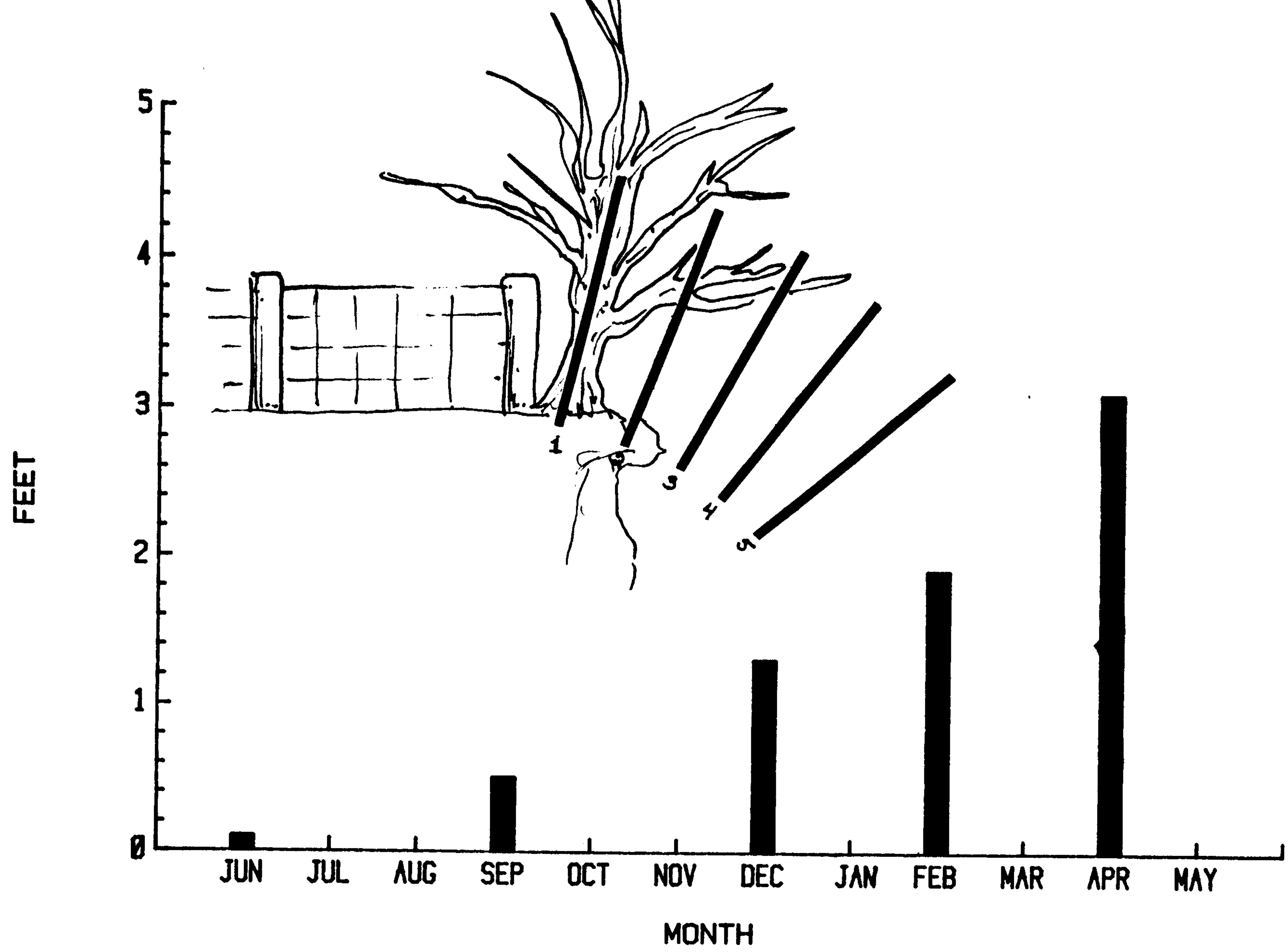


FIG. 15 Erosion recession for Lake Erie in Conneaut, Ohio. Measured in reference to a fence at the top of the bluff. Notice increase in spring due to thaw and excess drainage.

Drainage

Slump and creep are facilitated by wave action carrying away the toe or bottom of the bluff and also the presence of excess water. Drainage on this property is not well controlled. Septic tank overflow seeps down to the clay layer and runs out to the bluff on this plane, thus lubricating slump blocks. I also observed drainage tubes halfway down the hill(figure 16). The leakage from these tubes adds to the effect of surface runoff and sheeting that erodes the top three to four inches of soil. Gullies and rills penetrate the bluff and move several feet of material into localized areas. [18] Ground-water from precipitation affects the detrius in three ways:

1.Water seeps through the sand layer and flows out to the bluff face,and seep zones lubricate the clay layer.

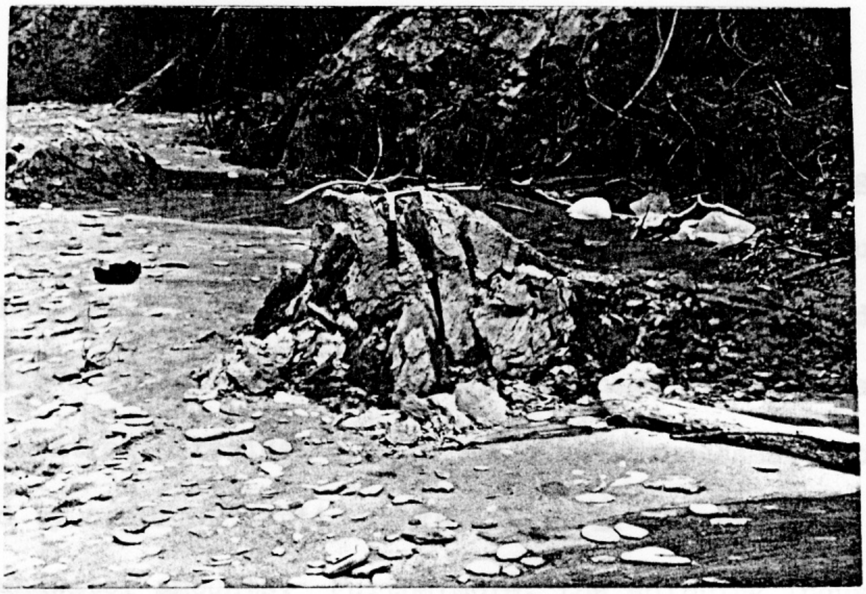
2.Water adds weight and weathers the soil.

3.Water increases water pressure in the soil and this decreases the natural cohesion, increasing instability and the rate of slump. [19]

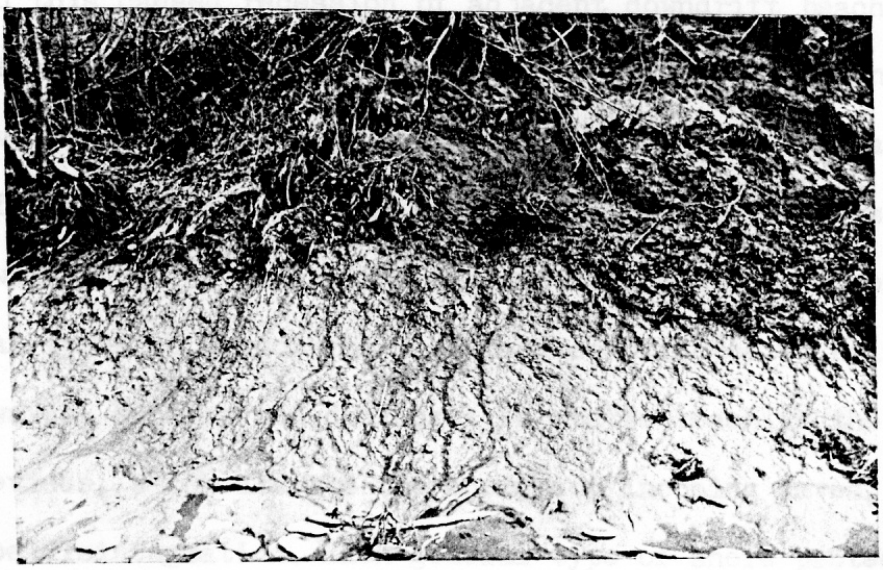
A

B

Figure 16. Drainage tubes located twenty feet below top of bluff adding water and weight to the bluff face. April 1982.



A



B

Figure 17(A) This is a slump block of sandy material that has slid over the clay layer at the bottom of the bluff on Laituri's beach. Wave action has reduced its size and broken it apart. (B) The stratigraphy of the bluff is shown with two distinct layers. Course-grained sandy lacustrine deposits on top are penetrated easily by rainwater. This water seeps out on top of the glacial clay layer.

Man's Intervention

Man has built homes and cottages on the shores of Lake Erie because of the aesthetic value of the envoronment. The weight of these structures has added to the instability of the bluff when built too close to the edge. Swimming pools at the top of the bluff diminish the effect of gravity, but add water to the drainage system. Paths down to the beach at each residence help the slump processes. Most sewage is filtered by overflow septic tanks that, if not properly drained, increase groundwater amounts. Furthermore, the shipping industry and private owners have built harbors, which interrupt the littoral transport of sand and this caused recession of adjacent downdrift beaches.[20] This is seen in the aerial photographs of Ashtabula Harbor in the Appendix. In twelve years a buildup of sediment can be easily seen at the junction of the breakwall and the shoreline. Property owners are now becoming aware of these situations and are taking steps to correct them.

Several types of structures have been constructed to halt the action of waves, erosion and drainage. A stable beach is the result of these devices, which absorbs the energy of incoming waves, thus reducing toe disintegration. Each general type of shore protection will be illustrated and the advantages and disadvantages of each will be stated. Some of these do not withstand the test of time, such as the wooden breakwall in fig. 23. Groins cause adverse affects to adjacent beaches, therefore careful considerations are taken into effect when making a decision to alter the natural course of erosion.

Site-Description and Results

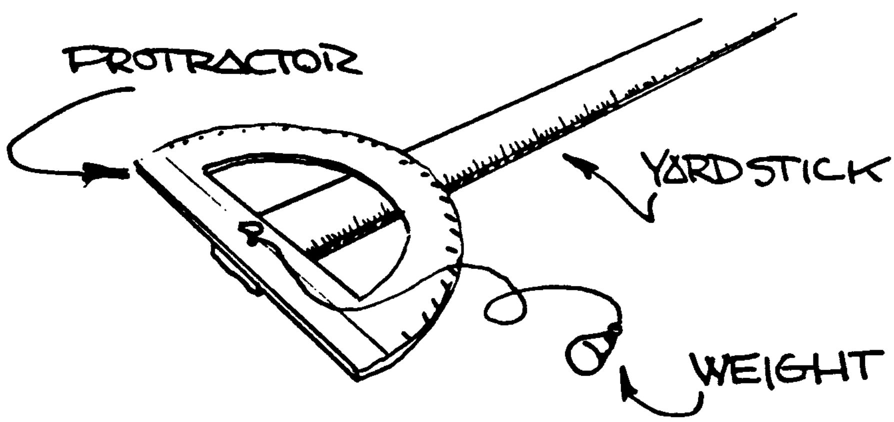
The Laituri residence, where the generalized site survey was done is located .63 miles east of Salisberry Road on Route 531(Lake Road). Their backyard extends to the lake with a steep thirty foot slope. The term bluff is used at this site because of the unconsolidated soil and the relief of the face. The results of the survey are listed and then summarized in figure 18 to determine the proper type of vegetation to be planted. These results may vary with location and time of the year.

Fetch ≈ 12 km- Average distance of open water measured perpendicular to shore and 45° to either side of shore.

Longest Fetch > 20 km - Longest distance of open water.

Shoreline Geometry = Straight shoreline.

Slope = Steep. 1 to 17.5 (vertical to horizontal); measured the bluff face with a protractor, yardstick and weight as shown. The yardstick is placed parallel to the bluff face. [21]



Sediment sample = fine sand and a gray fine-grained clay with crystalline clasts of size approximately 1-5 mm in diameter.

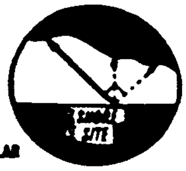
Boat Traffic = Conneaut Shipping Company; Navigation channel not within one km; three miles east.

Wind = Shore does not face in direction of prevailing winds or storm waves, but is affected by all wave movement.

Cumulative Wave Climate score = 21-30; plant 5-7 month seedlings of plugs at 1 1/2-foot spacings in 20-foot zones. The score is on the edge of solution of no planting. This will vary with area.

Rate of Recession = 3.1 feet per year. See figure 15 where the rate of slump is determined for this bluff. Literature sited is close.

Stratigraphy = The layers of soil in this area are an important factor in determining the slump seen. At the toe, a clay-sized glacial till with angular pebbles and poor sorting is approximately two meters thick. This bluish clay of approximately Cary age is overlain by a layer of old sandy lake deposits with rounded and polished grains deposited from a glacial lake of higher level. This top weathered bed slides easily over the saturated clay layer to the lake. See figure 17 B.

1. SHORE VARIABLES	2. DESCRIPTIVE CATEGORIES (SCORE AS INDICATED)						3. SCORE
a. FETCH - AVERAGE AVERAGE DISTANCE IN KILOMETERS (MILES) OF OPEN WATER MEASURED PERPENDICULAR TO THE SHORE AND 45° EITHER SIDE OF PERPENDICULAR 	Score : 0 LESS THAN 3.0 (1.8)	Score : 2 3.1 (1.9) to 6.0 (3.7)	Score : 4 6.1 (3.8) to 9.0 (5.6)	Score : 6 9.1 (5.7) to 12.0 (7.5)	Score : 8 12.1 (7.6) to 15.0 (9.4)	Score : 10 GREATER THAN 15.0 (9.4)	6
b. FETCH - LONGEST LONGEST DISTANCE IN KILOMETERS (MILES) OF OPEN WATER MEASURED PERPENDICULAR TO THE SHORE OR 45° EITHER SIDE OF PERPENDICULAR 	Score : 0 LESS THAN 4.0 (2.5)	Score : 2 4.1 (2.6) to 8.0 (5.0)	Score : 4 8.1 (5.1) to 12.0 (7.5)	Score : 6 12.1 (7.6) to 16.0 (10.0)	Score : 8 16.1 (10.1) to 20.0 (12.4)	Score : 10 GREATER THAN 20.0 (12.4)	10
c. SHORELINE GEOMETRY GENERAL SHAPE OF THE SHORELINE AT THE POINT OF INTEREST PLUS 200 METERS (600 FT) ON EITHER SIDE	Score : 0 COVE		Score : 2 IRREGULAR SHORELINE		Score : 4 HEADLAND OR STRAIGHT SHORELINE		4
							
d. SHORE SLOPE SLOPE OF THE PLANTING AREA (VERTICAL TO HORIZONTAL) 	Score : 0 GRADUAL 1 to 15 OR LESS			Score : 4 STEEP MORE THAN 1 to 15			4
e. SEDIMENT GRAIN SIZE OF SEDIMENTS	Score : 0 SILT & CLAY	Score : 2 FINE SAND	Score : 4 MEDIUM SAND	Score : 6 COARSE SAND	Score : 8 GRAVEL		2
f. BOAT TRAFFIC PROXIMITY OF SITE TO NAVIGATION CHANNELS FOR LARGE VESSELS OR SMALL RECREATIONAL CRAFT	Score : 0 NO NAVIGATION CHANNEL WITHIN 1 KILOMETER (0.6 MILES)		Score : 8 NAVIGATION CHANNEL WITHIN 1 KILOMETER (0.6 MILES)		Score : 16 NAVIGATION CHANNEL WITHIN 100 METERS (330 FT)		0
g. WIND THE ORIENTATION OF THE SITE IN RELATION TO LOCAL WINDS	Score : 0 SHELTERED FROM WIND		Score : 4 DOES NOT FACE IN THE DIRECTION OF PREVAILING WINDS OR FREQUENT STORM WINDS		Score : 8 FACES IN THE DIRECTION OF PREVAILING WINDS OR FREQUENT STORM WINDS		4
4. CUMULATIVE WAVE CLIMATE SCORE							30

SCORE = 1 TO 10: USE SPRIGS AT 3-FOOT SPACINGS IN 10-FOOT (MINIMUM) ZONES.

= 11 TO 20: USE SPRIGS OR 15-WEEK SEEDLINGS AT 1½-FOOT SPACINGS IN 10-FOOT (MINIMUM) ZONES.

$\boxed{= 21 \text{ TO } 30:}$ USE 5-7 MONTH SEEDLINGS OR PLUGS AT 1½-FOOT SPACINGS IN 20-FOOT (MINIMUM) ZONES.

= ABOVE 30: DO NOT PLANT

Figure 18. Site evaluation form for marsh plants. (After U.S. Army Corps of Engineers, 1980).

Shore Protection Devices

The purpose of this section of the report is to explain examples of different types of shore protection. It must be cautioned however, that while these solutions are considered low cost, they do involve considerable investment. The State of Ohio Department of Natural Resources has agree to help finance private as well as public protection from erosion. A letter must be submitted to state the problem, site, and residence involved. The Chief Engineer will assess your case and hopefully be able to help financially if it is an urgent case. [21]

A breakwater is an offshore permanent or floating structure placed parallel to the shoreline approximately fifty feet offshore. The important factor to consider in the construction of this is the height, so that the waves will break over it in a proper amount to create diffraction of the waves on the shoreward side. These shallow waves will form a beach if the breakwater is placed correctly. Figure 19 shows a breakwater that decreases the energy of incoming waves and forms a rounded beach.

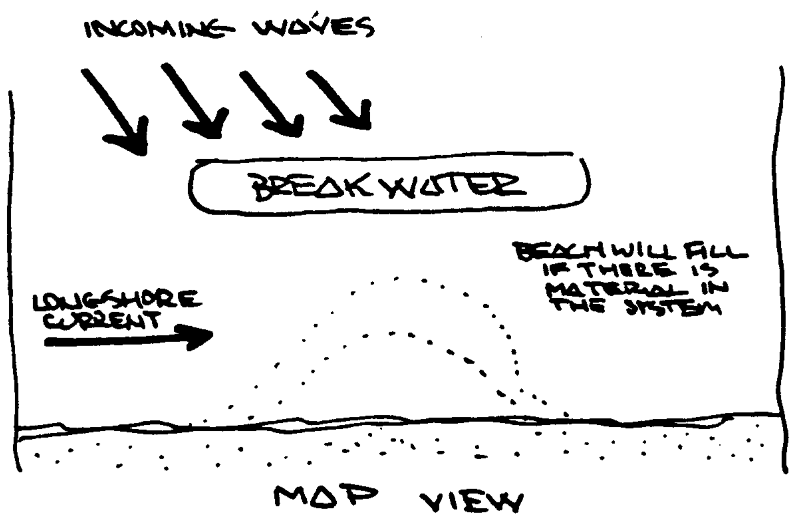


Figure 19. Breakwater effects and results. (Taken from U.S. Army Corp of Engineers, 1981).

A groinfield is a series of fingerlike projections set up perpendicular to the shore. Their primary purpose is to trap and retain sand, nourishing the beach compartment between them.[22] The groins interrupt the littoral drift system, building up sand on the updrift side. As equilibrium of the system is reached, the transport of sand continues as it was before construction and a stable beach is maintained. Groins offer limited protection during storms, but as the waves break on the beach their energy dissipates here rather on the toe of the bluff. One disadvantage of groins is the broken beach with cement pilings. Figure 20 shows the processes involved with groins.

Two other major devices are used on various shorelines; the seawall and revetment. The seawall protects bluffs by completely separating land and water acting primarily as a restraining wall for sediment. The studied bluff is too high for this structure; it is usually found in bays and low sloping areas. Disadvantages include appearance and the loss of a sandy beach. See figure 21 for illustration.

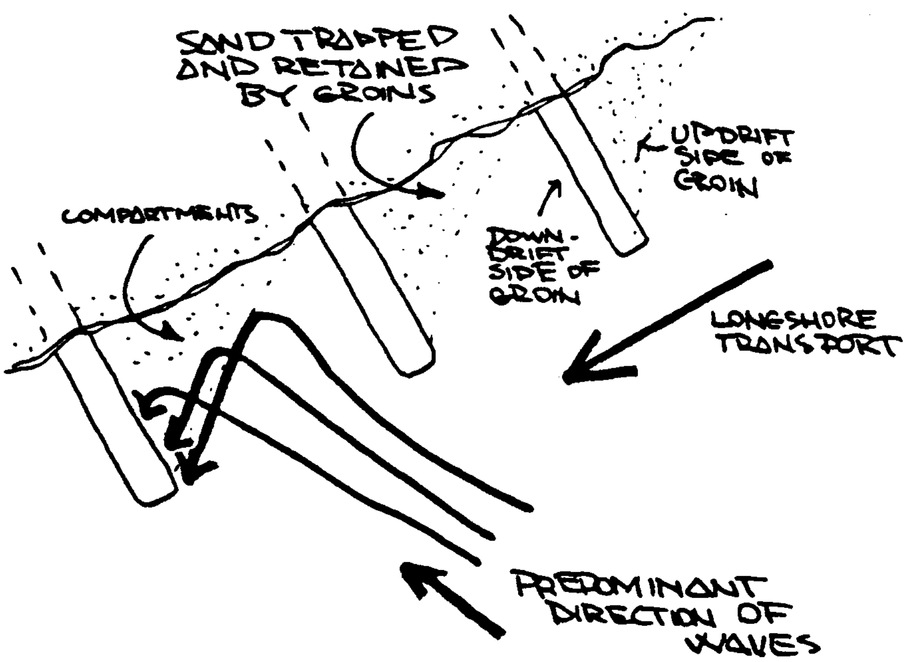


Figure 20. Groin and littoral transport interaction. (Taken from U.S. Army Corp of Engineers, 1981).

Revetments are made of durable cement blocks or rubblemound that is placed along the slope of the shore. It serves as a surface for the waves to break upon without destroying the underlying slope. If this area bluff angle was decreased greatly it could be used here, although there is a loss of the beach and it is impractical. Figure 22 shows the revetment and construction considerations mentioned hereafter.

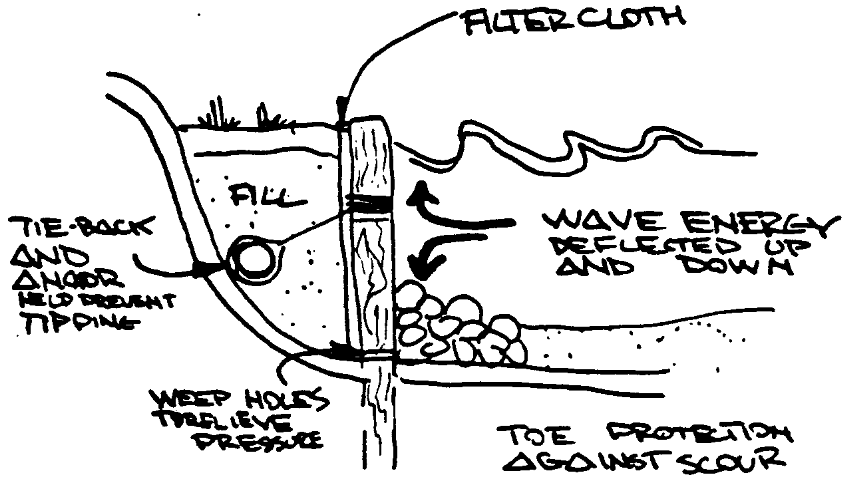


Figure 21. Seawall and its construction considerations. (Taken from U.S. Army Corp of Engineers, 1981).

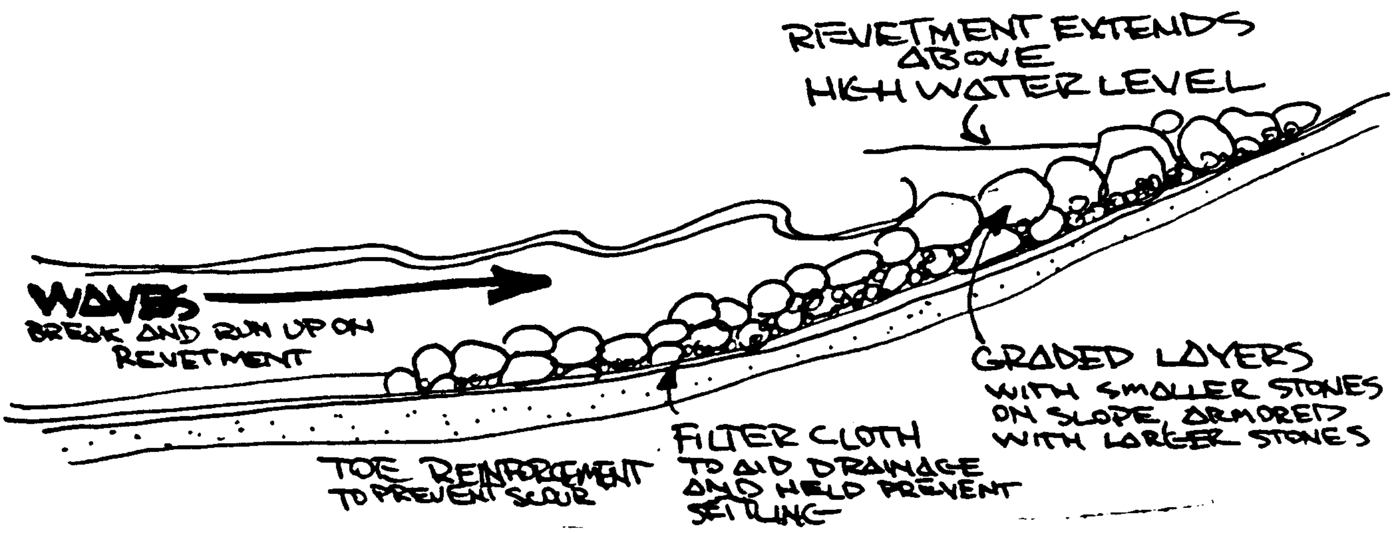


Figure 22. Revetment. (Taken from U.S. Army Corp of Engineers, 1981).

Materials used for groins and breakwaters include cement blocks, rubblemound, gabions (rocks in wire mesh), rubber tires, timber piles, and sand filled rubber tubes called Longard tubes. Tires, timber, tubes and the gabions seem to break over a short period of time or are vandalized. Rubblemound and formed concrete are the longest lasting materials as long as the proper construction guidelines are followed. Concrete formed blocks run at a price of $100 - $300 per foot and the rubblemound is about $150 - $150 - $250 per foot.

As preventive measures, five things that need to be considered in the construction of these structures are:

1. Toe protection - a wide base is established with rubble piled in graded layers to prevent scour (which loosens the whole structure).
2. Foundations conditions - there should be a smooth bottom and a filter cloth used between the structure and the bottom to stop settling.
3. Ties - both ends of the structure made secure to stop movement.
4. Height - if it is too high it will seriously interfere with the shore processes and if it is too low the waves will break over its top.
5. Materials used - the right size of material must be used so that wave action does not dislodge it.

Consultation and construction with a reputable firm is highly recommended for stabile and accurate protection. Remember that these devices must withstand the test of time and storms. Figure 23 shows a retaining wall that failed in about 20 years. Other actions will also help one's erosion problem. Decreasing the slope angle to a ratio of 1:15 inhibits downslope movement by gravity. Just west of Laituri's, the bluff was leveled and excess vegetation was planted. It seems to be effective. See figure 24.

Figure 23. This retaining wall was built just west of Laituri's house in the early 1960's. Slump blocks on the high bluff and the weight of the tree in the right corner pushed through this wooden wall.

Figure 24. Just west of Laituri's the bluff was leveled with bulldozers. Added vegetation and clearing of trees has stabilized this gentle slope. There is no slump, just some imperceptible creep.

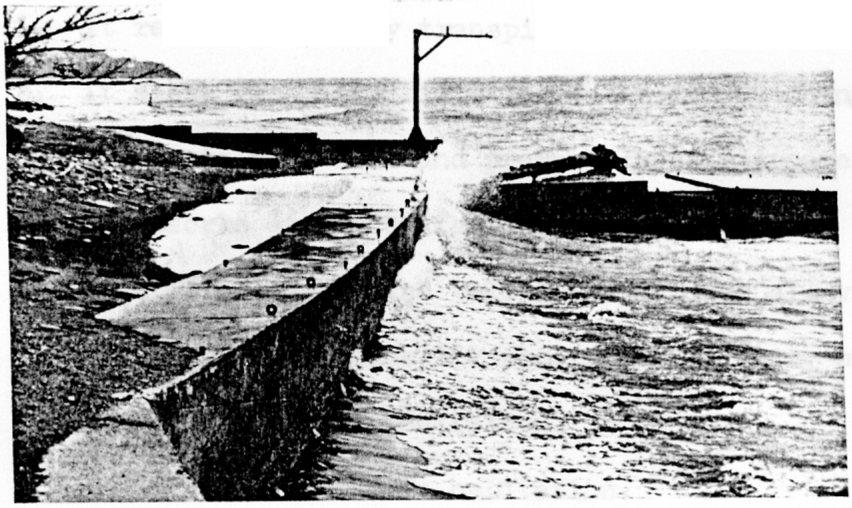


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Figure 25. Two sets of groins that both develop a beach. (A) These sturdy groins are three houses west of Laituri's on Lake road. They are nineteen years old. They were expensive to construct and have caused recession on the adjacent shore property, but have stopped wave action considerably. (B) A less expensive groin field is constructed at Harrington Point, .1 mile east of Laituri's. Cement was pored into smaller blocks and also steel drums further up the shore, but tires were useless. The beach of about fifty yards was created over a longer period of time than A. Equilibrium seems to have been reached.

Vegetation has many advantages, as outlined below:

1. It removes water by transpiration and uptake.
2. It slows runoff by filtering water and catching sediment.
3. The roots hold soil and prevent layer slippage.
4. It absorbs energy of falling rain.
5. Vegetation slows wind velocity and traps alluvium.
6. Vegetation maintains the absorptive capacity of the soil.
7. It reduces frost penetration.
8. And provides wildlife habitation. [23]

The suggested plant mixture for inadequately drained areas is 15 lbs. of Reed Canarygrass, 5 lbs. of Garrison Creeping Foxtail. 5 lbs. of Red Top(Agrostic Alba), and 10 lbs. of Birdsfoot Trefoil. This should be planted every two months, starting in April. Vegetation is inexpensive, and stabilizing, but is also sensative to storms and humans.[24]

Drainage inceptors are recommended to lessen the amount of water in the lake bluff. They can be imbedded 10-15 meters landward on the top of the bluff to catch surface runoff of rains and groundwater seep due to the stratigraphy and septic tank overflow. This will prevent rill and gully erosion and reduce the concentration of water and therefore weight in the bluff face. Figure 26 shows the basic construction. Drainage pipes must reach the beach with durable material or this system will be useless.

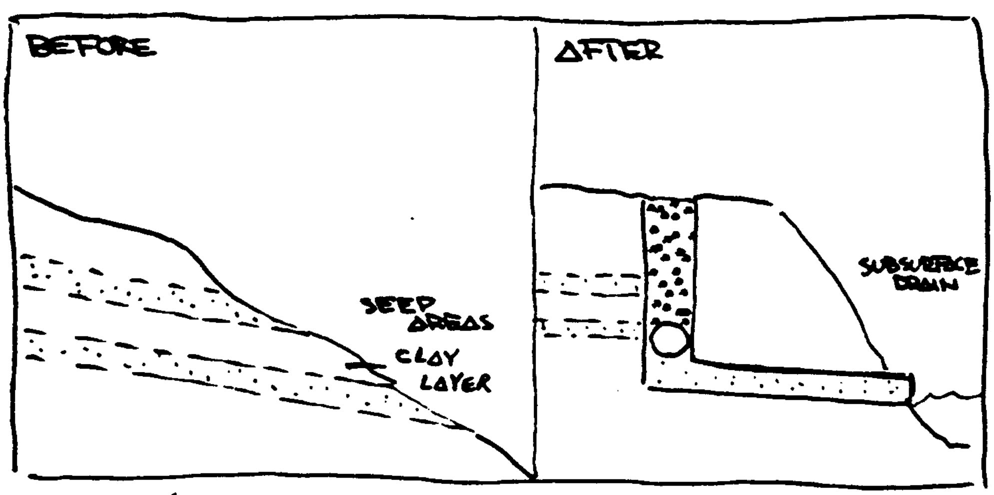

Figure 26. Drainage inceptors. (Taken from Clemens, 1972).

Recommendations

The values of the residential properties on the stretch of Lake Erie shoreline between Salisberry Road to Harrington Point in Conneaut, Ohio are too high to resolve to relocate, sell, or take no action against their evident erosion problem. The author suggests a combination of solutions to abate the rapid recession rate on this southern shore. Proper vegetation, drainage inceptors, and a series of groins will be a considerable investment, but in light of the life of these dwellings, a wise decision. The Chief Engineer should be contacted for further assistance financially and a contractor hired for the construction. Other advice includes better human intervention with the lake shore. A footbridge should be built to slow the movement of sediment downhill when families travel to the beach. In the future, building close to the bluff should be avoided, which is being considered in the new building codes. The trees that are on the top of the bluff should be cut down, leaving the roots for added vegetative stability. Their weight aids downslope movement as seen at many places along the study area.

Understanding the natural processes of erosion is the first step to overcoming the problem of bluff recession. If the landowner can slow down the inevitable recession found on all shorelines, he can preserve the many advantages of lakeside living. Taking needed steps now will insure future generations of the pleasures others have enjoyed.

Endnotes

[1]Ohio Department of Natural Resources, Division of Water, Coastal Zone Management, March 1982, Coastal Hazard Management: Shore Erosion, p. i.

[2]Hatcher, Harlan, and Erich Walter, 1970, A Pictorial History of the Great Lakes, p. 29.

[3]Carter, Charles H. and Donald E, Guy Jr., 1980, Lake Erie Erosion and Flooding: Erie and Sandusky Counties, Ohio Dept. of Natural Resources, p. 1.

[4]U.S. Army Corp of Engineers, 1981, Low Cost Shore Protection, (Golden and Halpern, Inc: Phil., Pa.), p. 7.

[5]Ibid, p. 18.

[6]Ibid, p. 19.

[7]Benson, Joe D., 1979, Lake Erie Shore Erosion and Flooding, Lucas County, Ohio, Ohio Department of Natural Resources, Division of the Geologic Survey, p. 14.

[8]Barnett, Douglas B., Nov.1979, Physical Processes Affecting Lake Erie Shore in Bay Village, Ohio, [Senior Thesis, Ohio State University], p. 25.

[9]Carter, Charles H., 1973, The November 1972 Storm on Lake Erie, Ohio Department of Natural Resources, Division of the Geological Survey, p. 19.

[10]Department of the Army, Detroit District, 1983, Monthly Report of Lake Levels for the Great Lakes.

[11]Carter, p. 4.

[12]New York Sea Grant Extension Program, Buffalo Division, U.S. Army Corp of Engineers, 1982, Water Levels of Lake Erie, p. 8.

[13]Ehlers, Ernest, and Harvey Blatt, 1982, Petrology: Igneous, Sedimentary, and Metamorphic Rocks, (W.H. Freeman and Son : San Fransico), P. 269.

[14]Christopher, James Ellis, 1959, Geology of the Ohio Shore of Lake Erie Between Fairport and the Pennsylvania Border, [Disr't: Ohio State University], p. 55.

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[15]Christopher, p. 137.

[16]Bloom, Arthur L, 1980, Geomorphology: A Systematic Analysis of Late Cenezoic Landforms, (John Wiley and Sons: New Jersey), p. 178.

[17]Krycrine, D.P., 1941, Soil Mechanics Its Principles and Applications, (McGraw- Hill: N.Y.), p. 37.

[18]Clemens, Robert, 1972, The Role of Vegetation in Shoreline Management, Great Lakes Basin Commission on Coastal Zone Management, p.17.

[19]Ibid, p. 8.

[20]Ibid, p. 22-23.

[21]Ibid, p. 23.

[22] Chief Engineer, State of Ohio,1981, Outline of Procedures for State Subsidy, Department of Natural Resources.

[23]Army Corp of Engineers, p. 18.

[24]Clemens, p. 19.

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APPENDIX

Glossary

1. Angle of Repose- The natural angle that a slope tends toward due to the type of material, weight, water saturation, and grain size.

2. Bluff- High, steep bank at the water's edge primarily composed of soil.

3. Clay- Extremely fine-grained soil with individual particles less than .0015 inches in diameter.

4. Creep- Imperceptible and nonaccelerating downslope movement. The material is termed colluvium.

5. Erosion- Wearing away of the land by natural forces. On a beach, the carrying away of sediments by waves, wind and tidal action.

6. Fetch- Area where waves are generated by wind that has steady direction and speed; length over which the wind travels.

7. Filter Cloth- Plastic cloth, woven of modern synthetic fibers that are permeable enough to allow water to pass through, but not sediment.

8. Glacial till- Unsorted, unstratified sediment that is deposited directly from glacial ice, without reworking by the meltwater. It contains angular fragments of rock.

9. Groin- Fingerlike projections of cement placed perpendicular to the shoreline to trap sand from the littoral drift system and retard the erosion of the shore.

10. Hydration- $CuSO_4 + 2H_2O \rightarrow CuSO_4 \cdot 2H_2O$(gypsum). Water attaches itself to a mineral and chemically forms another solution-derived mineral. A form of degradation found on the beach.

11. Hydrolysis- A chemical reaction between feldspars and micas with bicarbonate to form clay minerals and carbonic acid. Also found in the beach area.

12. Isostatic rebound- Process in which the crust of the continent rises up due to the release of pressure with the melting of the glacial mass.

14. Lacustrine- Sediments associated with a fresh water lake.

15. Littoral Drift- Movement of sand along the beaches in the near-shore zone, by prevaling winds and oblique waves.

16. Oxidation- $2FeS_2 + 6O_2 \quad Fe_2O_3 + 4SO_4$. Iron-rich sediments in the upper later of bluff weather to heavier hematite.

17. Revetment- A facing of stone, concrete, etc., built to protect a scarp, embankment, or bluff fron erosion and wave attack.

18. Recession- The net landward retreat of coastal bluffs over time due to erosional processes.

19. Rubble- Loose, angular, waterworn stones of broken rock used for construction of groins and breakwaters.

20. Scour- Removal of underwater material by waves of currents, especially at the toe of wave protection devices.

21. Seawall/ Bulkhead- A structure separating land and water by pilings or lumber that prevents erosion and damage by wave action. The bulkhead prevents sliding of land into the lake.

22. Slump- Rotational movement of blocks of land along a convex surface of rupture.

23. Stratigraphy- The natural sequence of layering of sediments with time.

24. Toe Erosion- Erosion that occurs at the base of a bluff as a result of continuous removal of earthen materials by waves.

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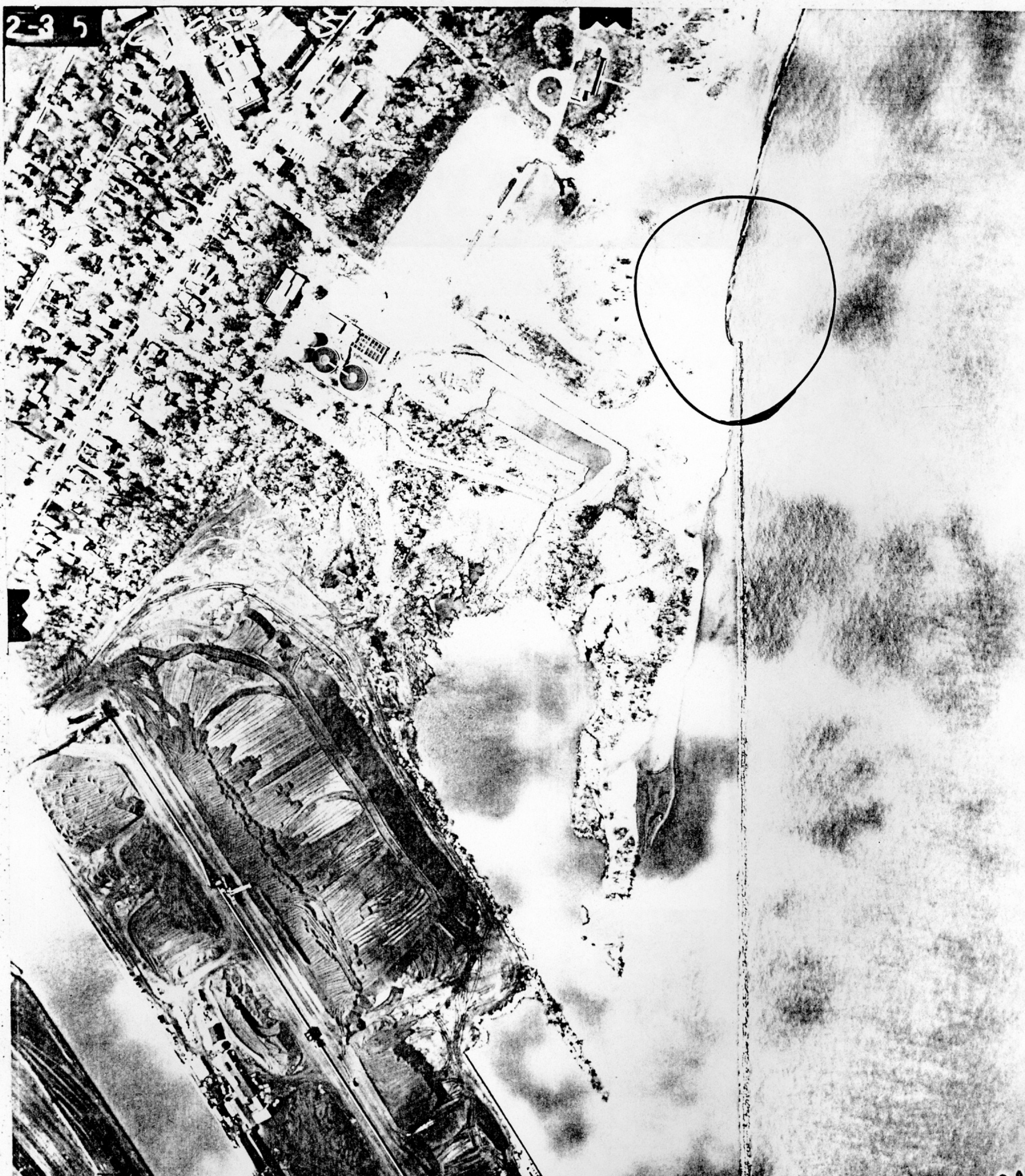

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